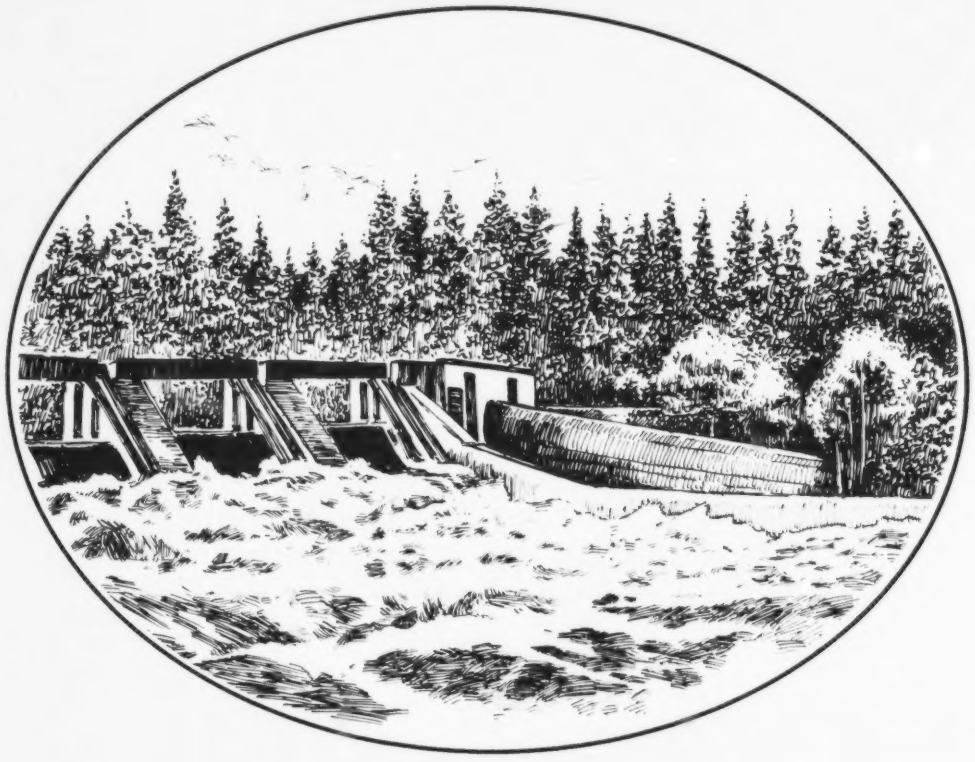
SMALL HYDRO

A Natural For Ontario



A guide to Ontario's Small Hydro Assistance Programs

Ontario

Ministry of Energy

Honourable Vincent G. Kerrio Minister

SMALL HYDRO

Ontario

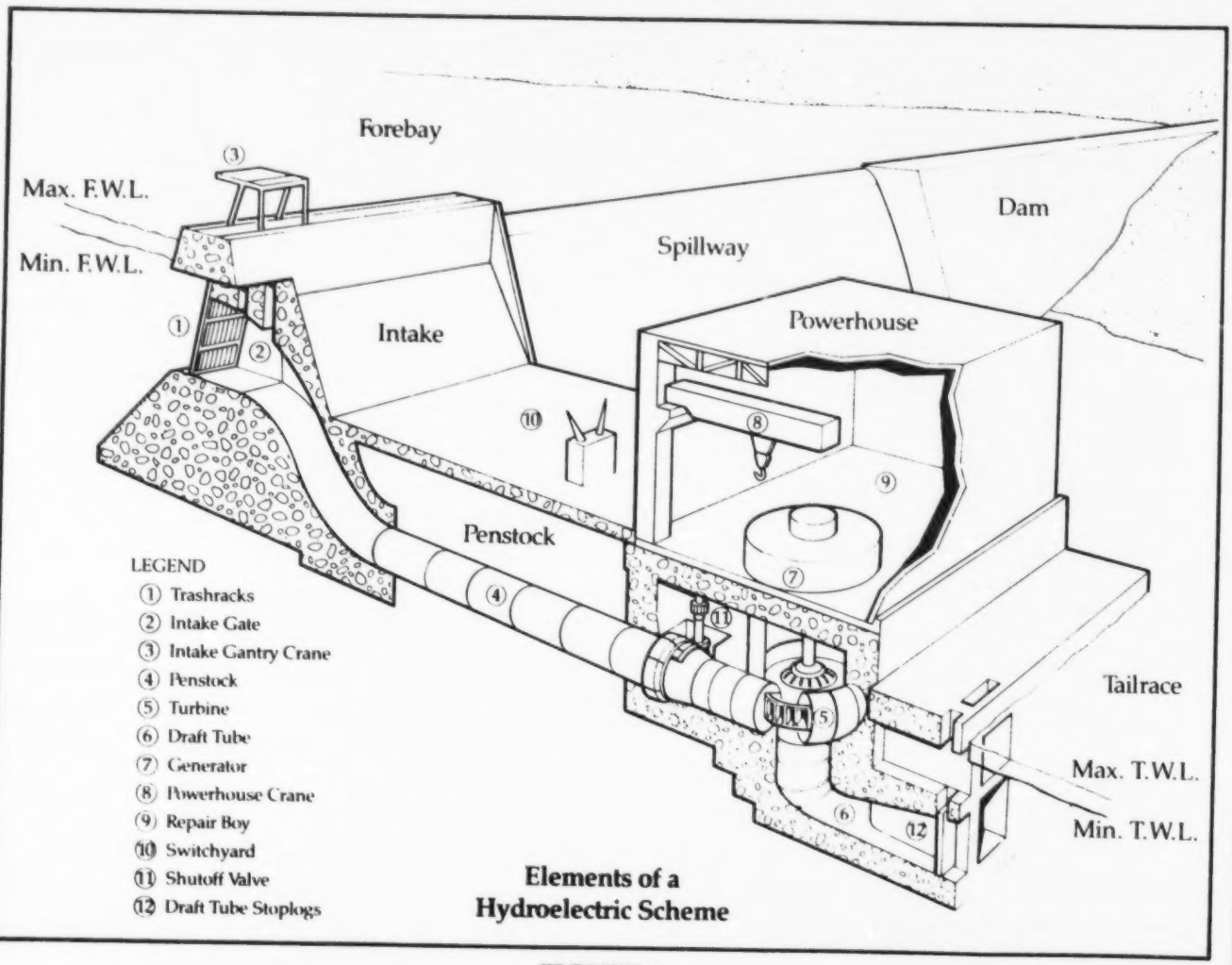
SMALL HYDRO

1. Introduction

Since early 1981, the Government of Ontario has undertaken a Small Hydro Encouragement Program to assist the development of the province's small hydro-power sites.

This booklet describes the Program and the various forms of assistance available to individuals, businesses, local communities and other prospective small hydro developers. In addition, it provides basic information on the development process for small hydro sites in Ontario.

2. What Is Small Hydro?



Elements of a Hydroelectric Scheme

FIGURE A

A hydroelectric power plant converts the kinetic energy of a flowing stream of water into electricity (Figure A). Since the water is continually replenished by natural precipitation, hydro-based energy is an indigenous, renewable resource. The water is harnessed by a dam, or diversion, and directed through a hydraulic turbine. The flowing water turns a turbine, which is coupled to a generator to produce electricity. After passing through the turbine, the water is returned – essentially unchanged – to the stream or river.

Small hydro systems are defined as having energy-producing capacities of a few kilowatts up to 20 MW (megawatts), to meet loads ranging from a single household, up to a large industrial plant or a small town. By connecting the output of a small hydro plant to the electric utility's grid, even a small plant can contribute to electricity needs elsewhere in the province.

3. Ontario's Small Hydro Resources

Ontario is blessed with abundant hydropower resources. Many of our towns and cities were originally founded near good hydropower sites, and hydropower provided all of our electricity until the early 1950s. To date 7395 MW, or 56 per cent of our hydropower resources, has been developed – with over 90 per cent of this power from large sites.

With over 30,000 lakes and rivers, many viable small hydro sites remain in Ontario. These include 225 previously abandoned sites that could be brought back into production, and another 500 sites at existing dams where generating facilities could be installed.

The exact number of undeveloped sites, particularly in Northern Ontario, is simply unknown. Altogether, an estimated 1,000 MW of small hydro potential is thought to exist in the province.

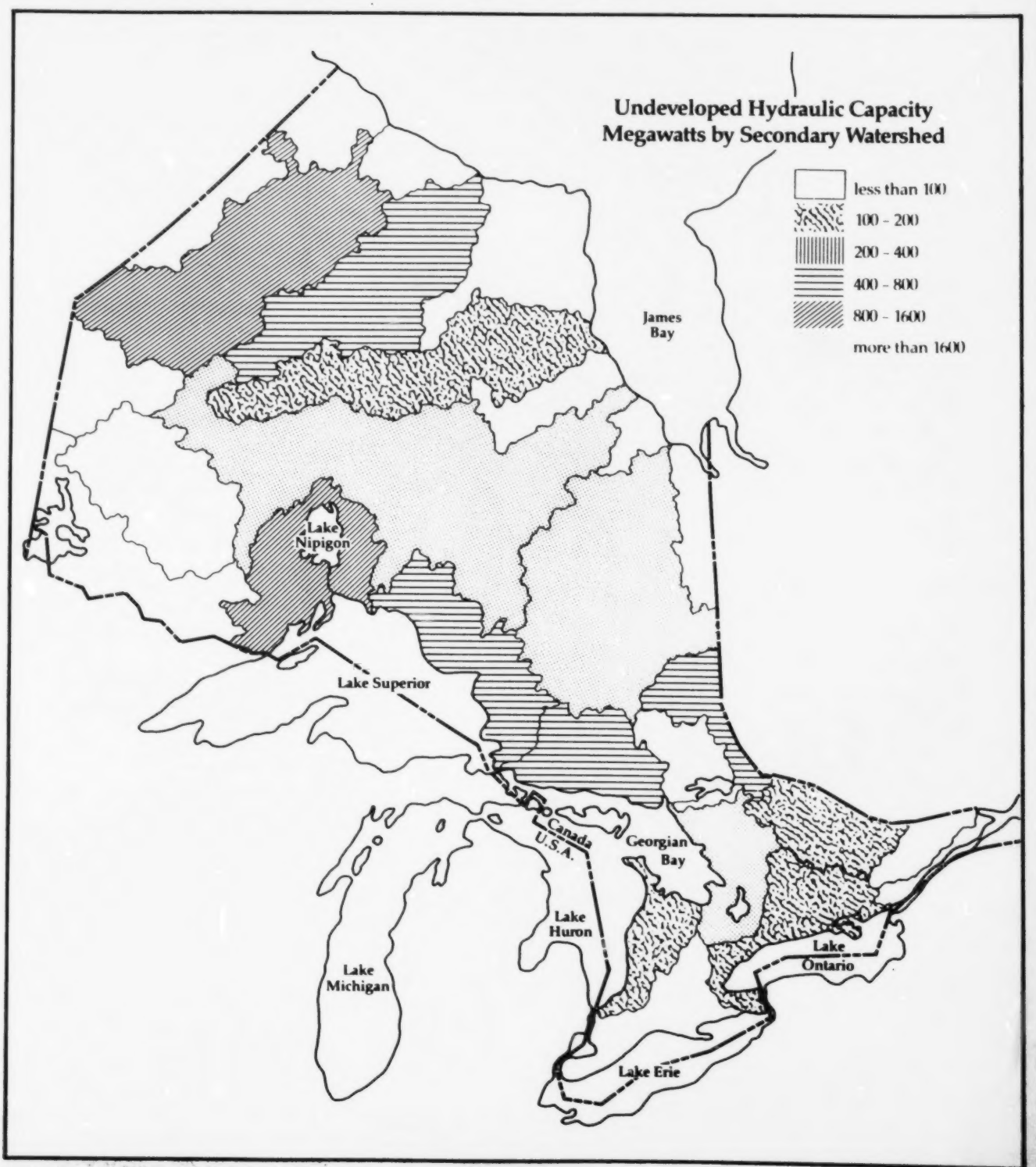


FIGURE B

4. Benefits Of Small Hydro Development

The development of these small hydro sites contributes to the province's energy security in an environmentally acceptable manner, while lowering energy costs and stimulating both business and employment.

Environmental Acceptability.

Hydro electricity is non-polluting and produces no waste heat. Adverse environmental impacts are usually negligible and, for most small installations, are non-existent.

Security of Supply.

Small hydro is indigenous, renewable and long-lived. A properly-designed small hydro plant can operate for a century or more.

Economical Power.

Once the capital investment has been repaid (in five to 15 years), the running costs of small hydro plants are very low, often in the range one to two cents/kWh. By comparison, retail electricity currently costs about five cents/kWh and remote diesel generation costs five to 10 times this amount.

Industrial Development.

Not only is hydropower a domestic energy resource, but we have all of the manufacturing, engineering and financial capability required to develop it within the province of Ontario. Using the experience gained in Ontario's small hydro market, this industry today exports over 60 per cent of its production, creating permanent jobs for Ontario residents.

5. Elements Of A Small Hydro Plant

A hydroelectric plant converts the energy available from running or falling water into mechanical energy, which in turn provides electricity.

The physical layout of a hydro plant depends on the natural conditions of the site – its topography, hydrology and other related factors.

Most hydroelectric plants have some basic features in common: an inlet works; a waterway to convey water to the turbine; a hydraulic turbine; and the electrical generator and switchgear.

Inlet Works.

The water for a small hydro plant can be drawn directly from a lake or river, or from behind a small dam. The inlet works include the structures involved in directing the water towards the turbine. Enclosed in the inlet is a trash rack to prevent debris from entering the turbine, and causing damage. Provision must be made for periodic cleaning of the trash racks, and also for preventing the formation of ice.

Waterway.

The function of the waterway is to convey water from the inlet works to the turbine, with minimum losses. A waterway can be either an open canal, or a closed penstock.

Hydraulic Turbines.

There are two major types of hydraulic turbine: impulse and reaction. An impulse turbine, such as a Pelton Wheel (Figure C), utilizes a high-velocity jet of water that strikes bowl-shaped brackets to extract kinetic energy from the water. Impulse turbines are best suited to high-head installations, where the water has a large drop in level (eg. in mountains). These sites are not common in Ontario.

Reaction turbines develop power from the combined action of the kinetic and pressure energy of the water. Two basic types, the Francis turbine (Figure D), and the propeller turbine (Figure E), are commonly used in Ontario. In the Francis turbine, the flow enters at the side and turns down, while in the propeller turbine the flow is always along the turbine's axis.

The amount of power produced by any hydraulic turbine depends on both the flow of water through the turbine and the head (or drop) of the water under which the turbine operates. The potential power is determined by the combined efficiency of the turbine and the generator. This is expressed by the following formula:

$$\text{Power in kW} = 9.806 \times Q \times H \times e$$

Where Q is the flow of water in cubic metres/second, H is the head in metres, and e is the efficiency – usually taken as 85 per cent. The diameter, and hence the cost, of a turbine is directly related to the flow it must handle.

Generator and Switchgear.

Electrical generators are of two types: induction or synchronous. The induction generator is controlled by the 60-cycle frequency of the utility grid while the synchronous generator's frequency is self-controlled. Synchronous generators are commonly used in larger, grid-connected plants – or in off-grid locations, where a stable frequency is essential.

Switchgear includes the electrical apparatus to protect and control the generating plant. The local electrical utility will specify its requirements for connection to the grid, but in all cases the installation must comply with the *Canadian Electrical Code*.

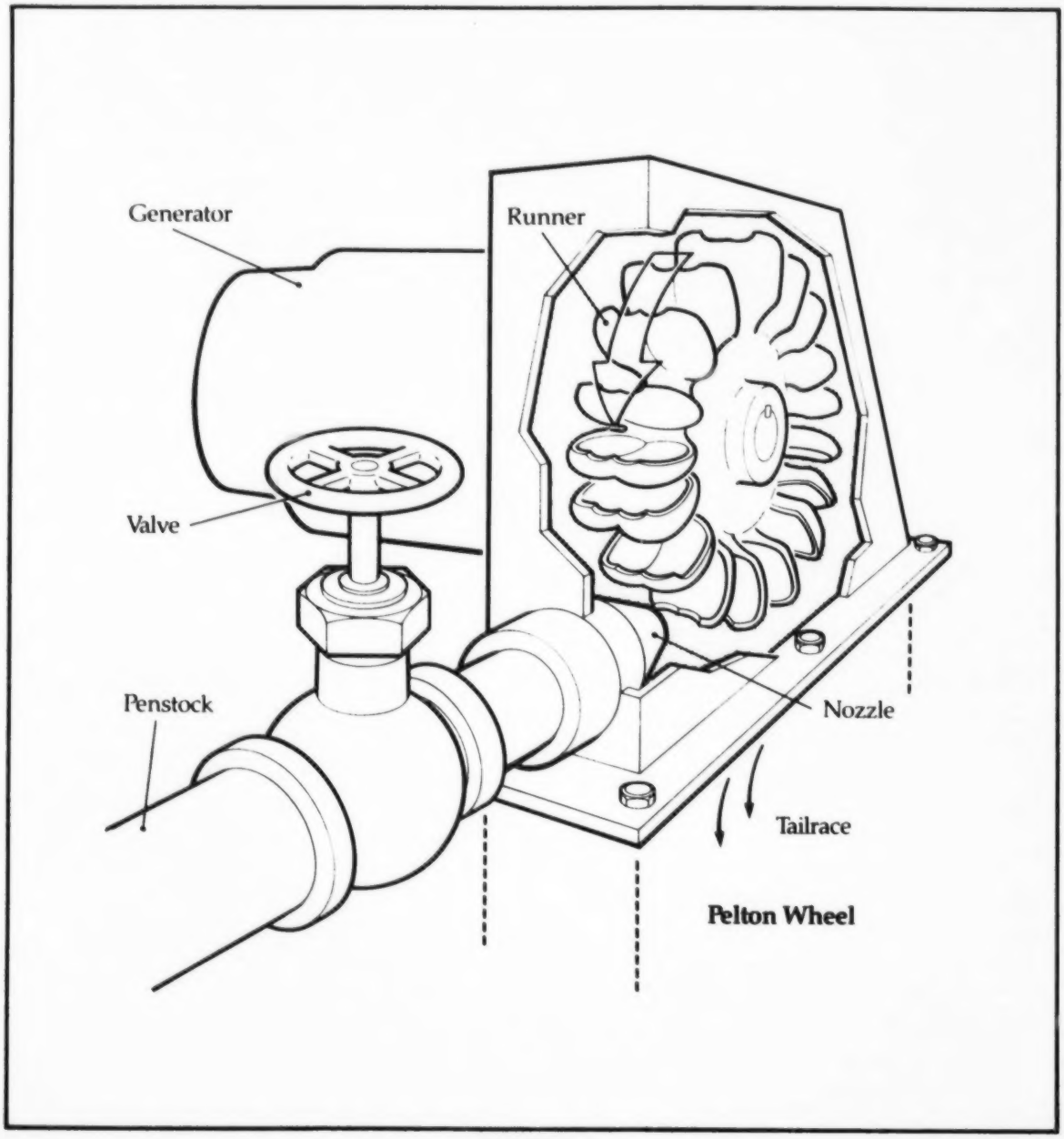

Generator
Runner
Valve
Penstock
Nozzle
Tailrace
Pelton Wheel

FIGURE C

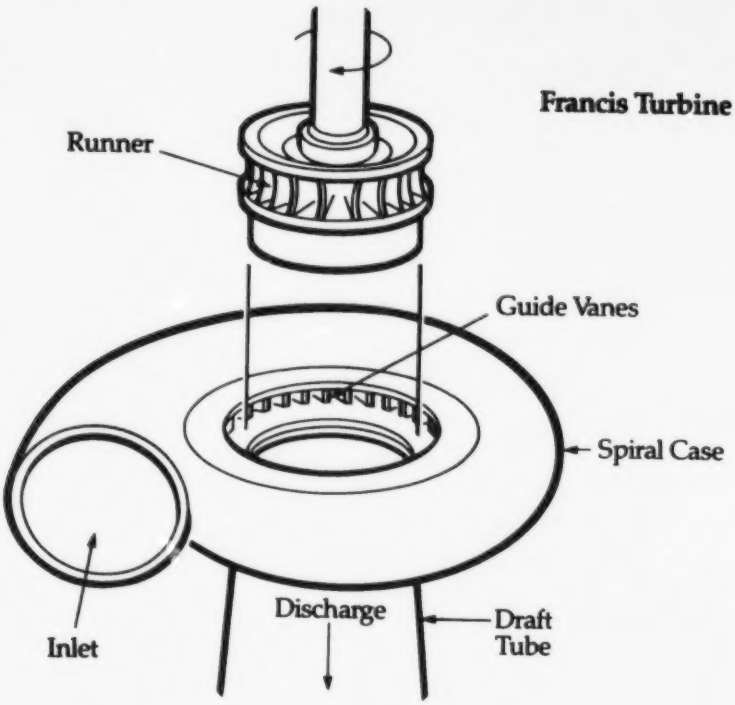
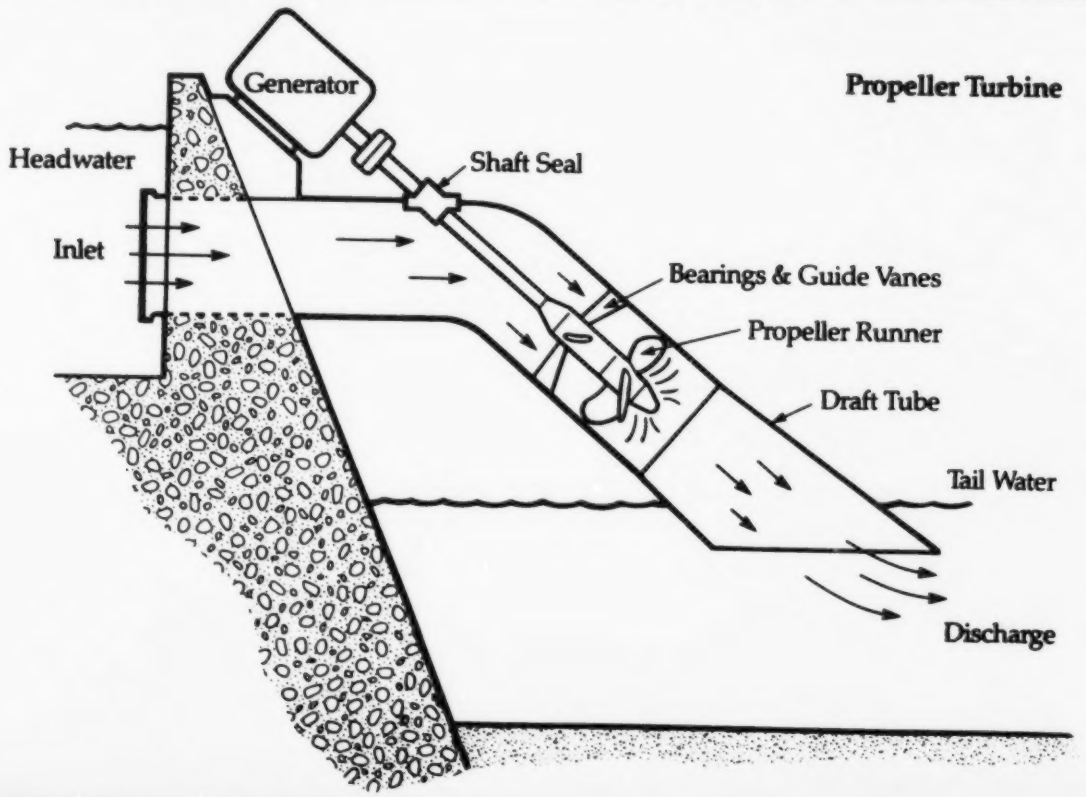

Francis Turbine
Runner
Guide Vanes
Spiral Case
Inlet
Discharge
Draft
Tube

FIGURE D


Propeller Turbine
Generator
Headwater
Shaft Seal
Inlet
Bearings & Guide Vanes
Propeller Runner
Draft Tube
Tail Water
Discharge

6. Economics Of Small Hydro

The cost of a small hydro installation depends upon many site-specific factors. Among these are the head available at the site; the available flow and its fluctuation through the year; the need for special structures, such as a dam or powerhouse; and the distance that the power must be transmitted to the electricity grid, or where the user needs it.

These costs can be estimated by a qualified engineer who is familiar with the conditions at the site. A rough idea of the costs of developing typical small hydro sites in Ontario can be gained from Figure F, which shows the cost in dollars per kilowatt for different capacities, heads and types of projects. Note that the cost decreases as either the head or capacity increases.

Whether a site is economic depends upon the developer's expectations, and also upon the willingness of banks, or other investors, to provide financing for the project. With electricity valued at five cents/kWh, a site might be considered attractive to private investors if the total development costs are less than $2000/kW.

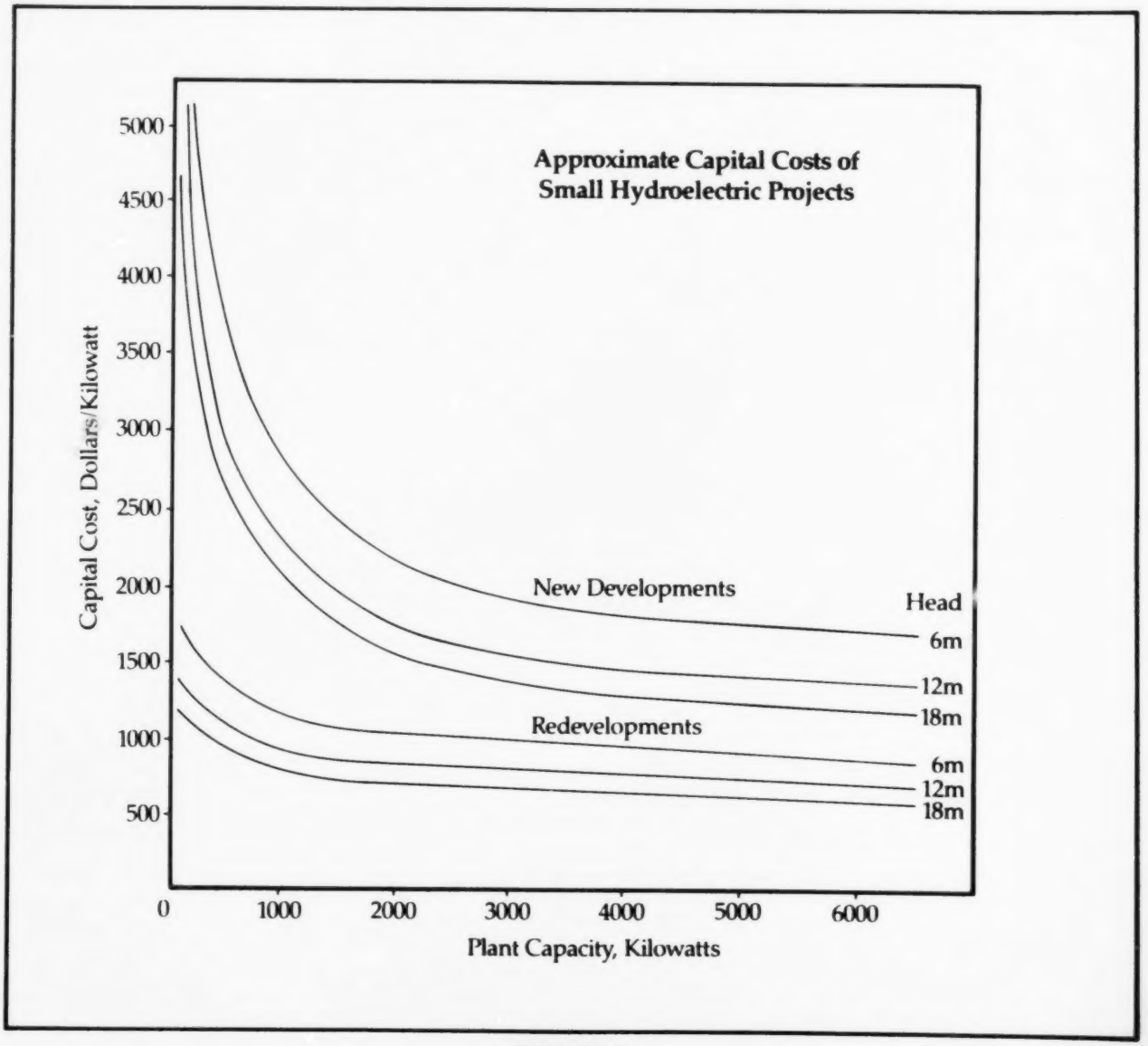


FIGURE F

7. Who Can Develop A Small Hydro Site?

Small hydro projects have been successfully undertaken by individuals, private companies, conservation authorities, municipal utilities and others. More than 20 such projects - totalling over six MW - have been completed in Ontario since 1980, and another 65 MW of capacity is currently in various stages of development.

At Frontier Lodge near Elliot Lake, the owners - John and Betty Middleton - used the Ministry of Energy's Northern Small Hydro Program to install a small hydro system. They now have a reliable, secure electricity supply, at considerably lower cost than their previous diesel generator.

A much larger project was completed by the Upper Thames Conservation Authority. The Fanshawe Dam was originally constructed in 1952, to provide flood control on the Upper Thames river near London. In 1983, a 500 kW small hydro plant was retrofitted into this structure at a cost of $840,000. The power being produced by this small hydro system is now saving the conservation authority over $100,000 annually, and the surplus is being sold to Ontario Hydro.

8. The Development Process

The development of a small hydro site is usually motivated by the desire to earn an attractive return on investment. Small hydro development is essentially a business enterprise that involves many different activities, and should therefore be planned accordingly.

The development process can be separated into five distinct (though usually overlapping) stages. These are project identification, project investigation, approvals, power sales, and project financing and implementation.

Project Identification.

In this initial stage, the developer identifies a site with a potential for small hydro development. He/she formulates a business strategy and starts to organize the project. Often the developer already knows of a local dam, or a former power site that seems to offer an adequate head and flow. In other cases, sites may be identified using *Ontario's Water Power Sites*.

As a first step, it is very important to ascertain the ownership of the site - and to confer with the local district office of the Ministry of Natural Resources, to see if development would be subject to any constraints.

Project Investigation.

The investigation stage is usually performed in two parts. The first is a site assessment, to determine the technical and economic viability to the project. This will determine the feasibility of proceeding to the second part, which is a more detailed engineering, legal and financial investigation.

The site assessment should be undertaken by a qualified professional engineer, and should provide preliminary sizing of all major equipment, plus estimates of the costs and revenues of the proposed development. If the project appears feasible on the basis of this assessment, more detailed studies may be undertaken - culminating in final engineering design and the receipt of firm quotations from suppliers and contractors.

During the site assessment, the project should be reviewed with the Ministry of Natural Resources, potential investors, and - where applicable - the local electric utility. This will ensure that all important concerns can be identified and resolved early in the development process.

The requirements for detailed studies will depend on the size of the project, and the nature of the development.

Approvals.

Before construction can begin on any small hydro project, the developer must satisfy a number of legal and regulatory requirements. These are designed to protect the environment and to safeguard the rights of other land and water users. In Ontario, the bulk of these approvals are administered through the district offices of the Ministry of Natural Resources. (See pocket for additional information.)

Power Sales and Project Financing.

When the studies indicate that a project is technically feasible, and may offer an attractive return on investment, the availability of financing will depend largely upon the measures taken by the developer to reduce uncertainty and control risk. The principal risks are as follows:

a) The completion risk. If the project is not completed on time or within budget, the capital cost will go up.

b) The operating risk. If the project fails to produce the estimated output or income, the revenue needed to repay the investment will go down.

Measures to reduce the completion risk include the use of reputable engineers, suppliers and contractors, all working under clear legal contracts, with appropriate bonds, insurance and warranties, to guarantee compliance.

The major control over operating risk is the power sales contract with the utility. This must guarantee the price to be paid for power over the financing period, often 10 years. Further information on Ontario Hydro's power purchase policies is contained in the pocket at the back of this brochure.

Implementation.

Having completed the engineering design, obtained approvals, and successfully negotiated the power purchase agreement and financing, the developer can proceed to the implementation stage of the project.

A common method of implementing a project is to award contracts for procurement of equipment, and construction of facilities, based upon drawings and specifications prepared by a consulting engineer. An alternative method is the turn-key approach. This is where one contractor is made responsible for the entire implementation process, including design, procurement, construction and start-up.

With either approach, the implementation phase ends with the commissioning and acceptance of the plant. The commissioning procedure should be defined in advance, to ensure that all parts of the plant operate in accordance with the specifications.

The entire development process, from initial identification of the site to final commissioning of the plant, usually takes from two to five years in Ontario. The most significant factors affecting the project schedule are usually the lead times required for equipment delivery, and the availability of good weather for construction.

9. Small Hydro Encouragement Program

Ontario's Small Hydro Encouragement Program began in 1981 with the objective of "building a climate that would encourage the private sector and local communities to develop the province's smaller waterpowers."

In its first five years, the program was concerned with establishing an appropriate policy environment, including provisions for accessing crown-owned sites, and for the sale of power to utilities. Feasibility studies and demonstration installations were supported by the Ontario Ministry of Energy, to assist projects which pioneered small hydro development, and promote the growth of the provinces's small hydro industry.

As a result, policies for release of crown sites and for purchase of power from small hydro plants are now clearly defined (see pocket for details). In addition, Ontario's small hydro industry is developing its expertise from the experience gained from these demonstration projects - and exporting Ontario's small hydro technology all over the world.

Today, the program's main concern is to encourage more small hydro site development throughout the province - particularly in remote areas that are presently dependent on diesel generation for their electricity supply. To help accomplish this, the Ontario Ministry of Energy offers assistance to developers of small hydro sites for site assessment, for project evaluation and for Northern projects. These forms of assistance are described in the following sections.

10. Assistance For Site Assessment

The Site Assessment Assistance Program is planned to operate until March 1989.

Purpose.

Site assessment helps the developer obtain qualified professional advice on the costs, benefits and feasibility of developing a specific site.

Eligibility.

Any site owner or developer - whether an individual, company or municipality - who is a resident of Ontario and has legal access to the site for development, is eligible for this assistance.

The completion of a Site Agreement (or equivalent) is a pre-requisite for assistance for both Project Evaluation (section 11) and Northern Projects (section 12).

Assistance Provided.

For site assessments, the Ontario Ministry of Energy will contribute $2,000 plus reasonable expenses, to a maximum of $3,000.

The site assessment must be undertaken by a qualified professional engineer selected by the proponent. The engineer's minimal requirements will be to prepare a report on the site, in accordance with the Ministry's Small Hydro Assessment Reporting Package, "SHARP". This includes the following:

- collection of all available site data
- topographic and hydrographic surveys, as required
- hydrological analysis of the available flow
- preliminary layout to define the scope of the project
- preliminary sizing and selection of turbines and generators
- preliminary power and energy estimates
- preliminary cost estimates
- identification of power purchasers and prices
- an economic analysis of the project with consideration of its suitability for financing
- identification of any environmental, institutional or other constraints in developing the site.

A particular site will be assessed only once, and the SHARP report will be made available to the public.

Application Procedure.

The applicant must complete and submit the enclosed Small Hydro Application, indicating that a site assessment grant is being applied for.

The Ministry of Energy will provide a confirmation of eligibility and a copy of the "SHARP" report format, within ten working days of receipt of a complete application.

Terms of Payment.

Payment of the grant will be made on receipt of a report detailing the results of the work in the "SHARP" format, as well as copies of valid invoices and receipts for the professional services employed.

Applicant's Responsibilities.

The applicant is responsible for organizing the project, and for selecting the professionals to undertake the work.

11. Assistance For Project Evaluation

The Project Evaluation Assistance Program is planned to operate until March 1989.

Purpose.

Project evaluation helps the developer obtain qualified professional advice on project financing and related legal issues.

Eligibility.

Any site owner in Ontario who has an exclusive right to develop the site is eligible for assistance.

The completion of a Site Assessment (or equivalent) is a pre-requisite for project evaluation assistance, and must indicate that the development is feasible.

Assistance Provided.

For Project Evaluations, the Ontario Ministry of Energy will contribute 50 per cent of costs incurred, to a maximum of $5,000.

Financial evaluation includes professional consultations on legal and financial options, and includes professional services in negotiating financing or power sales agreements. The scope of work will depend upon the needs of the proponent and the specific conditions at the site - as briefly detailed in the application.

The evaluations must be undertaken by independent, qualified financial and/or legal professionals, and the results must be presented to the Ontario Ministry of Energy in a brief written report, which will be held confidential.

Application Procedure.

The applicant must complete and submit the enclosed Small Hydro Grant Application, indicating that a Project Evaluation grant is being requested. The applicant must attach to the application a copy of the SHARP report (or equivalent) and evidence of having legal rights to develop the site.

The Ontario Ministry of Energy will provide a confirmation of eligibility within 10 working days of the receipt of a complete application.

Terms of Payment.

Payment of the grant will be made upon receipt of a report detailing the results of the work, as well as copies of valid invoices and receipts for the professional services employed.

Applicant's Responsibilities.

The applicant is responsible for organizing the project and for selecting the professionals to undertake the work.

12. Northern Small Hydro Program

The Northern Small Hydro Assistance Program is planned to operate until March 1989

Purpose.

In 1985, the Ontario Ministry of Energy launched a new initiative to encourage the development of small hydro sites in Northern Ontario. This program is designed to assist commercial and industrial enterprises such as tourist lodges, mines and forestry operations, that currently depend on expensive diesel-electric generation. The program provides assistance for cost-sharing on the development of small hydro projects.

Eligibility.

The Northern Small Hydro Program provides financial assistance to eligible commercial and industrial business enterprises for the development, or redevelopment, of remote (off-grid) small hydro sites in Northern Ontario.

Eligible business enterprises include proprietorships, partnerships and corporations registered in Ontario, that operate business facilities in Northern Ontario, and that do not have access to the electric utility grid. Residential and community small hydro projects are not eligible for this program.

The majority of the power produced must be used for the applicant's business purposes, and must contribute to a reduction in business operating costs. The completion of a site assessment (or equivalent) is a pre-requisite for assistance for Northern projects, and must indicate that the development is feasible.

Assistance Provided.

For proponents undertaking projects up to 100 kW in capacity, the Ontario Ministry of Energy will contribute one-third of the estimated total eligible project costs, to a maximum grant of $70,000. Eligible project costs include the following:

- system design and engineering
- purchase and/or reconditioning of equipment
- civil works and structures (to a maximum of 25 per cent of project cost)
- penstocks and turbines
- electrical generators and switchgear
- connection to load
- construction and installation
- project management.

The Canadian-made content of the project must not be less than 75 per cent of the total project cost. All equipment must be warranted for a minimum of one year.

Assistance is also available for projects larger than 100 kW. Funding levels for these projects will be subject to negotiation up to a maximum grant of $300,000, and will also take account of the after-tax returns to the project. (Contact the Ministry of Energy for further details.)

In all cases, the Ministry of Energy's contribution will take into consideration the benefits of other forms of financial assistance.

Application Procedure.

Applicants must complete and submit to the Ministry of Energy the enclosed Small Hydro Grant Application, indicating that a Northern Project grant is being requested. The applicant must attach a copy of the SHARP report (or equivalent) and evidence of legal rights to develop the site.

The Ministry of Energy will provide confirmation of eligibility within 10 working days following receipt of the complete application.

The applicant will then proceed to finalize the design and obtain quotations for the necessary work from all suppliers and contractors. This information will be forwarded to the Ministry for evaluation and approval.

Grant Letter.

Following evaluation and approval of the project, the Ontario Ministry of Energy will forward to the applicant a letter detailing the terms, conditions and amount of the grant offered. This letter may then be presented to banks and other financial institutions.

The applicant will then forward to the Ministry – within 90 days of the date of the grant letter – all of the following:

- proof that the applicant has obtained the balance of funds required to undertake the project;
- copies of all permits and approvals required for the project;
- copies of certified installation drawings, equipment specifications and work schedule.

Reasonable extensions to the 90-day limit may be allowed, upon written application to the Ministry.

Terms of Payment.

As soon as the above conditions have been met, the Ministry will make an initial payment of 40 per cent of the total amount of the grant.

A second installment of 50 percent of the total amount of the grant will be paid when the Ministry receives proof of the following:

- substantial completion of civil work;
- delivery to site of all major equipment;
- payment of 50 per cent of the project costs (provide receipted invoices);

A final payment of 10 per cent of the grant will be paid when the Ministry receives the following:

- a commissioning report on the system, including load, flow and output measurements – and test results on all protection and control systems;
- a project cost breakdown showing the actual costs of the installation;
- copies of as-built drawings, specifications and manuals;
- color slides documenting all stages of the project;
- proof that all suppliers and contractors have been paid in full;
- copies of letters to all suppliers and contractors that the applicant has accepted the system.

Applicant's Responsibilities.

The applicant is responsible for organizing the project, selecting contractors and for obtaining all necessary permits and approvals. The applicant is also responsible for the design, installation, commissioning, operation and maintenance (for a minimum of five years) of the small hydro system. In addition, the applicant will undertake the following:

- designation of a project manager who will work together with the Ministry of Energy, and have the authority to conduct negotiations and submit reports.
- provision of free access to the staff of the Ontario Ministry of Energy, or its agents, for inspection during construction, start-up, and operation for a period of up to five years from the commissioning of the system.
- undertaking of performance monitoring of the installation for a period of one full year.
- assisting the Ministry in publicizing the installation, and allowing reasonable public access for purposes of scheduled demonstrations.

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SMALL HYDRO

Evolution In Ontario

The Rustic Past

Water power played a key role in Ontario's industrial development. In the early 1900s, many mills and factories were driven by electricity from hundreds of small independent hydro plants. After 1910, as Ontario developed a centralized electrical system, small hydro plants were gradually abandoned as uneconomical.

The Modern Revival—Government Leadership

In the early 70s, rising energy costs rekindled interest in small hydro plants. Many of the 570 formerly developed sites became economically feasible to return to production, and once again contribute to Ontario's energy security.

In 1981, the Ontario Ministries of Energy and Natural Resources began a program to encourage the development of small hydro sites. The program involved updating the inventory of available water power sites, assisting demonstration projects, funding feasibility studies, inspecting turbines, sponsoring conferences, and producing publications.

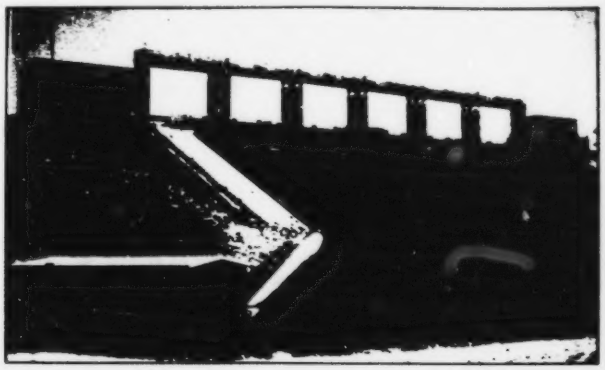
Ministry staff are also working to improve the financial climate, simplify regulatory approvals, reduce development costs, and stimulate exports of Ontario's small hydro products and services.

Today—A Multi-Million Dollar Industry

Today, small hydro again plays a key role in Ontario's industrial economy—both as a secure source of energy and as a major export industry. Ontario is recognized as a world leader in small hydro technology. Ontario's rapidly-growing small hydro industry produced most of Canada's small hydro exports—about $15-million in 1985.

Ontario

Helping To Build Energy Security For Ontario



The Fanshawe Dam was built in 1952 for flood control, and is typical of many similar sites in Ontario. Recently, a 500-kW small hydro plant, one of 12 government-assisted demonstration projects, was added. Ontario's Small Hydro Site Assessment Program offers assistance to municipalities, individual developers and conservation authorities to investigate similar sites throughout the province.

The Frontier Lodge small hydro facility demonstrates small hydro's potential for low-cost, secure energy supplies in remote areas without access to the provincial utility grid. Ontario's Northern Small Hydro Program offers assistance to business and commercial enterprises in remote areas of Northern Ontario, that currently depend on diesel fuel for electricity.

Helping To Build A New Industry For Ontario

Ontario's modern small hydro industry produces some of the most sophisticated and reliable equipment available in the world. Although this multi-million dollar industry is still young, sales are growing rapidly at 20 to 30 per cent each year. Ontario's Small Hydro Industry Development Program helps industry to improve technology and to expand markets.

This small hydro plant in Indonesia is one of many similar facilities around the world that have been built using Ontario's products and expertise. Ontario's small hydro industry is very competitive in the world market-place—a market that could be worth several billion dollars in the 1990s.

Small Hydro
Exactly what is it?

Small hydro is a water-power development with up to 20 megawatts in capacity. Smaller developments (under 100 kilowatts) are referred to as micro-hydro sites.

In Ontario, the capacity of most small hydro sites is less than two megawatts of electricity—enough to service 200 homes.

Ontario has more than 30,000 streams and rivers—hundreds of which represent potential sites for small hydro plants.

It has been estimated that 50 to 100 megawatts of new small hydro will be developed in Ontario by the year 2000. While this is a small amount by provincial standards, it could have a significant impact on local communities and businesses.

Some small hydro sites are connected to the province's utility grid, and it's often possible to negotiate with a local utility for the sale of surplus electricity. As well, Ontario Hydro has a purchase rate structure that encourages the development of independent generating facilities.

At non-grid sites, small hydro plants can greatly reduce energy costs by replacing costly, diesel-generated electricity.

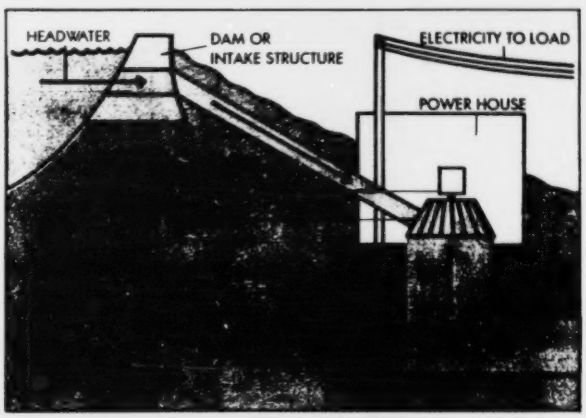


DIAGRAM OF A TYPICAL SMALL HYDRO PLANT

Small Hydro
Assistance Programs

Site Assessment

Provides assistance to prospective site developers in the initial engineering assessment of small hydro sites, and in the financial/legal evaluation of development options.

Grants of up to $3,000 will be provided for engineering assessment. For financial/legal evaluation, grants of 50 per cent of costs to a maximum of $5,000 will be provided.

Northern Small Hydro

Provides assistance to commercial and industrial businesses in remote areas of Northern Ontario not connected to the utility grid.

Offers grants of up to one-third of eligible costs for small or micro-hydro installations to displace diesel-electric generation.

Industry Development

Offers Ontario's small hydro industry assistance in improving small hydro technology and expanding export markets. Proposals for cost-shared projects will be evaluated on an individual basis.

For further details and application forms, contact:

SMALL HYDRO

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Or, call toll-free

Zenith 80420

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